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CONTRIBUTIONS TO THE PHYSIOGRAPHY OF THE PHILIPPINE ISLANDS: II. THE BATANES ISLANDS.[1]

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(*From the Division of Mines, Bureau of Science, Manila, P. I.*)

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[1] The first paper of this series, Cebu Island, by Warren D. Smith, was published in *This Journal* (1906), 1, 1043.

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INTRODUCTION.

This paper, embodying results of work during three weeks spent in geologic reconnaissance in the Batanes Islands, is intended to be preliminary to an article which will deal more fully with the geology and petrography of this group; hence the problems of structural geology will be in the main reserved for the later discussion and I shall here confine myself principally to the physiography.

Before proceeding to a description of this group, I wish to acknowledge my indebtedness to Major-General Leonard Wood, commanding general, Philippines Division, to Commissioner Dean C. Worcester, to Mr. William Edmonds, supervising teacher of the Batanes Islands, for his unfailing hospitality and for much helpful information, and to the native teachers and boys of his schools, particularly Mr. Jose Aguedo, for their freely rendered services as guides during my stay in the islands.

LOCATION.

The Batanes Islands form the most northern portion of Philippine territory and consist of the islands of Y'Ami, Maysanga,[2] Mabudis, Siayan, Isbayat, Inem, Batan, Sabtan, Ibujos and Desquey, of which Isbayat, Batan, Sabtan and Ibujos are inhabited. They lie between latitude 20° 16′ and 21° 05′ north (21° 13′ north if the *"existence doubtful"* Bashi rocks are included), or approximately the latitude of the southern half of the Hawaiian Islands, and between longitude 121° 49′ and 122° 02′ east. Y'Ami, the most northern island, is about 270 kilometers from Cape Engaño, the nearest point of Luzon, 107 kilometers from the Japanese island of Little Botel Tobago and 160 kilometers from the southern point of Formosa. It is said that on a very clear day the Formosan mountains can be seen from the summit of Mount Iraya in Batan Island. The Bashi Channel with a minimum depth of 1,009 fathoms separates the islands from Formosa and the Botel Tobagos to the north, while on the

[2] Where the local name differs from that given on the United States Coast and Geodetic Survey chart, I have followed the local usage. This chart, based on a British survey made in 1845, is badly confused as to local names, and is unreliable in regard to details of topography. On the maps reproduced in this paper the names are corrected to conform to local usage.

south the Balingtang Channel (depth of 95 fathoms without bottom) lies between them and the Babuyanes. The Balingtang Islands, lone rocks rising perpendicularly from the sea, lie in the center of the Balingtang Channel and form a connecting link between the Batanes and the Babuyanes groups.

PEOPLE.

The Batanes people form a separate race, speaking their own language, or languages, for that of Isbayat is different from the language of the other islands. Professor Scheerer [3] considers the inhabitants of Batan and Sabtan to be of Malay stock, while those of Isbayat are mixed Malayan and Papuan. They are kindly, intelligent, enterprising and extremely industrious. Throughout the Babuyanes and northern Luzon the Batanes people have the reputation for being excellent workers. The two principal islands, Batan and Sabtan, are overpopulated and the arable land is largely taken up, hence there has been considerable emigration and one finds people from the Batanes scattered throughout the Babuyanes Islands and Luzon.

In the days before the Spanish occupation, the constant warfare between the villages made purposes of defense the first requisite in the choice of a village site, hence the inhabitants lived on the hilltops, going down to work in the fields by day, after the manner of the Pueblo Indians of America. The ruins of these old towns are to be seen on the hills above San Vicente (Batan) and Itbod. Itbod was extremely elaborate, being built more in the form of a single fort than a village. Remains of a large cistern and of storehouses show that the inhabitants were prepared to resist a siege, and ruins of small buildings, apparently watchtowers overlooking the cultivated patches, show the precautions which were taken against surprise. It was here that the natives made their only stand against the Spaniards, being overcome by cannon planted on a neighboring hill.

With the coming of the Spaniards the hill towns were destroyed and the people forced to move into seacoast villages, the sites of which were as a rule dependent upon the presence of gaps in the coral reefs.

HISTORY.

The group was discovered by William Dampier in 1687 and named by him the Bashi Islands, after an intoxicating drink brewed from sugar cane (now however termed *palic* by the islanders). Later in the same year three Dominican missionaries visited the Batanes, but after the death of two of them, the survivor returned to Luzon. In 1724 four Dominicans arrived and stayed for a short time, but it was not until 1791 that the Spanish régime was fully established. From September,

[3] Scheerer, Otto: *Mitt. der Deutsch. Gesellschft. f. Natur und Völkerkunde Ostasiens*, Tokyo (1906), 11, Pt. I.

1897, to December, 1899, the islands were under the control of the revolutionary government.[4]

The present name *Batanes* has been used on Spanish maps since the Spanish occupation, but until a few years ago the original name of Bashi Islands was used on American maps, as it is on the English and German of to-day. Professor Scheerer[5] considers two groups; the Bashi Group which consists of Isbayat and the small northern islands, and the Batanes which are composed of Batan, Sabtan, Ibujos, and Desquey. Professor Kôtô, in his articles on the Malayan Archipelago and the dependent isles of Taiwan, makes the same division.[6]

CLIMATE.[7]

Rainfall.—The records of the Weather Bureau covering Santo Domingo de Basco for the years 1903–1906 are given in Table I. These show a very heavy annual rainfall, the tenth heaviest recorded and no very marked rainy season such as is found on the west coast of Luzon, where the records of Vigan (Ilocos Sur) show that 92.9 per cent of an average annual rainfall of 2,134.1 millimeters occurs during the rainy season from June to October. The seasons in the Batanes may best be defined as a short, dry season from February to May and a long, rainy one. Extreme differences of monthly rainfall such as those between May, 1905 and 1906, are due to typhoons. In May, 1906, two typhoons passed near the islands causing a precipitation of 153.8 millimeters on the 18th and 19th of the month and 390.8 on the 28th, 29th and 30th.

TABLE I.—*Monthly rainfall at Santo Domingo de Basco for the years 1903 to 1906, inclusive.*

Month.	Millimeters of rainfall in—				
	1903.	1904.	1905.	1906.	Mean.
January	270.1	306.8	150.2	327.6	163.7
February	27.2	66.7	85.5	12.5	48.0
March	51.8	20.0	154.8	119.9	86.6
April	141.0	10.2	89.0	207.5	111.9
May	201.1	110.3	21.0	677.0	252.4
June	163.6	262.7	151.0	90.1	166.8
July	340.7	406.5	267.6	202.0	304.2
August	910.7	377.0	207.6	127.4	405.7
September	186.9	168.6	186.1	424.1	241.4
October	734.1	151.3	370.8	618.6	468.7
November	310.8	121.2	123.0	190.8	186.4
December	344.3	363.5	227.6	361.9	324.3
Total	3,682.3	2,364.8	2,034.2	3,359.4	2,860.1

[4] From historical note contributed by William Edmonds to Philippine History, vol. 44.

[5] *Loc. cit.*

[6] Kôtô, B.: *Jour. Coll. Sci.* Tokyo (1899), **11**, II, 118 and (1900), **13**, I, 46.

[7] Statistics from Monthly Bulletins of the Weather Bureau for 1904, 1905, 1906, and Maso, Rev. M. Saderra, S. J.: The Rainfall in the Philippines, Manila (1907), Weather Bureau.

Typhoons.—The islands lie in the track of numerous typhoons which often completely destroy the crops and reduce the inhabitants to the verge of starvation. The houses are all built of stone for protection against these winds and at the times of typhoons, nets are stretched across the roofs and anchored to the ground. Typhoons of the first, third, and fifth groups, amounting to 63 per cent of the total number, affect the Batanes Islands.[8]

Temperature.—Table II gives the mean monthly temperatures for Santo Domingo de Basco compared with that of Manila for the years 1904 and 1906. It will be seen while there is very little difference in the mean temperature, the range is much greater in the Batanes than in Manila, being over 6° for the former and less than 4° for the latter.

TABLE II.—*Mean monthly temperatures in Santo Domingo de Basco and in Manila for the years 1904 and 1906.*

Month.	1904.		1906.	
	Santo Domingo de Basco.	Manila.	Santo Domingo de Basco.	Manila.
January	21.4	25.1	22.7	25.1
February	21.5	25.4	24.0	26.1
March	23.6	26.2	23.8	26.8
April	26.0	26.9	26.5	29.2
May	27.3	27.8	27.8	28.7
June	27.3	27.2	28.4	28.0
July	27.0	26.7	28.7	27.8
August	27.7	26.8	28.8	27.3
September	27.2	26.2	28.0	26.7
October	26.4	26.3	25.9	26.4
November	24.0	25.0	24.5	25.3
December	21.8	23.9	23	25.0
Mean	25.1	26.1	26	26.9

GEOGRAPHICAL DESCRIPTION.

The geologic structure upon which the topography of the islands is largely dependent naturally brings the Batanes into three groups:

1. The islands consisting in greater part of the older rocks, volcanic agglomerate with basic dikes. To this group belong the Island of Sabtan and southern part of Batan.

2. The younger volcanic group, consisting of Mount Iraya in Batan, the Island of Inem and the small islands to the north of Isbayat, locally known as the Siayanes.

3. The coral limestone group, Desquey, Ibujos and most probably Isbayat.

[8] Algue, Rev. Jose, J. S.: The Cyclones of the Far East, Manila (1904), 247.

SABTAN.

The Island of Sabtan is the southernmost of the Batanes Group. It is about 10 kilometers long by 4 broad and contains five villages, San Vicente, Santo Tomás and Santa Rosa on the east coast, Santa Inés and San Luis on the western side. From Point Natao southward on the east coast to within half a mile of Santa Rosa, there is no marked relief along the shore, with the exception of some high bluffs of volcanic agglomerate just south of San Vicente. Coral reefs extend over a large part of the coast, although their development here is not as extensive as on the west coast. South of Santo Tomas there is a long, flat stretch near the shore and here sand dunes reaching to a height of about 100 feet have dammed back the waters from the interior, forming a line of small ponds.

The land from the eastern shore rises toward the center of the island in a rather irregular series of marine terraces. The materials forming these terraces are stratified pebbles and sand, for the most part entirely unconsolidated, together with limestone, the latter both limestone conglomerate and coral limestone. These terraces when viewed from the neighboring island, Batan, seem to be beautifully regular, but on closer examination they are seen to be absolutely without continuity, probably due to the fact that where the protecting capping of limestone is absent, the terrace of pebbles and sand is soon worn away. The highest ledge of limestone occurs at an elevation of about 180 meters. It is a quarter of a mile inland and contains poorly preserved *Orbitoides*. Beyond the last terrace, the country is very deeply dissected and consists of irregular, sharp ridges of volcanic agglomerate, generally much decomposed.

A belt of rolling upland between a half mile and a mile wide extends diagonally across the island from Santa Rosa to Santa Inés. This has an average elevation of about 300 meters; it is bounded on the east by a sharp and very irregular escarpment of volcanic agglomerate. The valleys in this upland are broad and the small streams seem to be at grade, the topography being best described as "gently rolling," in marked contrast to the sharp feature of the irregular ridges below, in general it is a region of physiographic "old age." This upland rises gradually to the westward, the pass a half mile northeast of San Luis having an elevation of 400 meters, and it ends in a sharp line of cliffs broken only by occasional steep canyons. These cliffs extend along the whole west coast of the island, being lower (200 meters) towards Natao Point. The material is almost entirely volcanic agglomerate, with occasional beds of stratified sandstone and conglomerate which consist entirely of volcanic material. This rock where it occurs is much faulted, the faults being of small throw, generally less than 10 feet, and also somewhat distorted, showing small dips to the west and northwest. Of course, the folding and faulting are not confined to those parts of the agglomerate formation in which the

sandstone occurs, but it is only where there are bedded deposits that distortion is readily distinguishable.

Between Santa Inés and San Luis at an elevation of about 7 meters, there is a raised beach consisting of pebbles and a limestone conglomerate which also contains many volcanic pebbles. This beach is of so recent a date that the streams from the plateau have not yet had time to cut channels through it. From Natao Point, southward to Tangel Point, there extends an unbroken coral reef of considerable width. At the bay just north of Tangel is a flat, triangular stretch of marshy land formed by the ponding back of a small stream by the beach. Here there was a village until recent years, but because of its unhealthy situation it was abandoned and the land given over to cultivation, being almost the only piece of cultivated land on the west coast of Sabtan.

The southern portion of Sabtan is extremely rugged. It consists of sharp, irregular ridges of agglomerate ending in steep cliffs. The western part is impassible by land and at the time of my visit the sea was too rough to attempt the trip by boat. On the east coast I was able to travel as far south as Point Ajao. Here, steep cliffs of agglomerate, often cut by large dikes of hornblende and augite porphyry (f. n.) jut into the sea. No raised beaches or limestone were seen, but for about 8 meters above sea level the rocks were pitted as if by the borings of marine animals. The ridges of agglomerate seem to run in a general southeasterly direction, meeting the shore *en echelon* and forming a series of small points. The principal ridge, Ceskid Mountain, ending in Ajao Point, shows a remarkably serrate skyline.

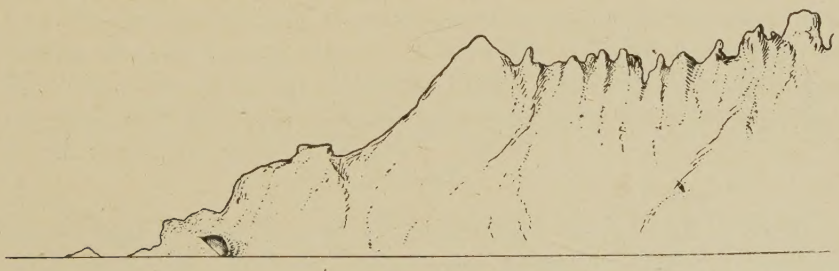


FIG. 1. CESKID MOUNTAIN AND AJAO POINT.

BATAN.

Batan Island is about 20 kilometers long, lies in a northeasterly southwesterly direction and varies from less than 2 kilometers to nearly 6 in width. The topography of the island falls into two distinct parts—first, the extreme northern end, northward from Santo Domingo, which is dependent on Iraya Volcano, and second the southern and by far the larger portion, which shows an independent topography which in many respects is similar to that of the Island of Sabtan. Aside from Mount Iraya, the principal topographic feature is a range of hills extending

diagonally across the island from Mabatuy Point on the west coast to Desiay Point, the southeastern corner of the island. This ridge rises abruptly from the sea at Mabatuy Point and extends southeast for about 2 kilometers where it reaches its highest elevation of about 460 meters at the twin peaks of Mount Matarem, thence it runs nearly south for a little over a kilometer, then turns southeast again, and where the Itbod gorge cuts through the ridge its direction is nearly east. (See Pls. II and III.)

Various spurs run off from the main ridge in all directions, and the topography is extremely confusing. A prominent ridge, with minor subsidiary ones, runs eastward from Chaua Point across the island. Another ridge extends eastward from Mount Matarem, the latter forming, with the main southeasterly ridge a large amphitheatral valley drained by the streams flowing through the Itbod gorges. The material of these ridges is all volcanic agglomerate, with occasional outcrops of igneous rock and scattered areas of stratified sandstone and conglomerate. The agglomerate ridges are sharp and ragged in their upper portions and are cut by streams in deep box cañons. The lower parts and the smaller spurs are covered by a thick mantle of decomposed material, generally in the form of a red clay with partly decomposed volcanic pebbles. The gradual downward creeping of this material on the hillside has given a rough stratification parallel to the contour of the hill. The agglomerate ridges form steep cliffs when they reach the sea as they do at Chaua and Mabatuy Points at the coast northwest from Itbod, and along the east coast of the island south from Eskid Bay (north of Mananioy). Where they are fissured, deep sea-caves are produced.

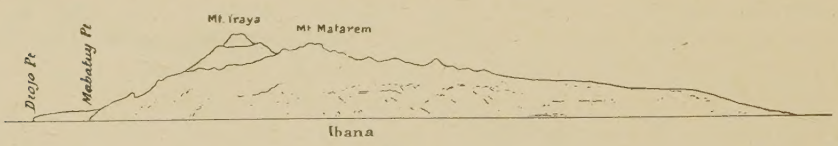


FIG. 2.

South of San Jose de Ibana there is a series of terraces very similar to those of Sabtan, but rather more regular, reaching a maximum elevation of about 275 meters and consisting of stratified volcanic material, sand, gravel and pebbles.

Northern Batan, north of a line drawn across the island from San Carlos de Magatao, shows an entirely different style of topography, the features of the landscape being controlled by the extinct volcano, Mount Iraya. This mountain is a beautifully symmetrical cone, its height as given on the Coast Survey chart being 3,806 feet (1,160 meters). The photograph (Pl. VI) shows that it was once of greater height, an older and larger cone having been blown away in a former eruption and a new

one built up in the old explosion crater, while on the southern side there is a hill of tilted basalt which may be the remains of a still older crater. The present crater is horseshoe shaped, being broken down on the northern side where the last lava flow, a stream of basalt, has emerged. Numerous, small fissures are seen in the crater and one cuts across its southern wall. These fissures are probably the result of earthquakes. Nearly all the lava flows are basalt, but the earliest seem to be andesite, although no petrographic study of them has as yet been made.

The end of the flow of basalt from the present crater is exposed in a sea cliff on the northern shore of the island, and this tells in some detail the story of the last eruption of Mount Iraya. The mountain had been quiescent for a period long enough before the eruption to allow a considerable stream valley to be cut through the bedded deposits of volcanic débris which form the cliffs of this neighborhood. The renewal of its activity was marked by considerable explosive force which probably blew away part of the northern side of the present cone and nearly filled the valley with a mass of angular fragments of volcanic material. The latter part of this explosive phase was marked by the presence of a number of basaltic bombs. Finally, a stream of basalt several feet thick flowed down this valley, completely filling it. Since then the lava flow has itself been buried under the mass of loose material constantly creeping down the slopes of the mountain.

The nearly flat region around Santo Domingo and stretching across the island owes its form to the piedmont wash from Mount Iraya. The hyperbolic curve of the mountain must at one time have been continuous from sea level to summit, but marine erosion has cut off the lower end, leaving sea cliffs varying from 15 to 60 meters in height truncating the piedmont plain and of much greater height where the waves have encroached upon the actual slope of the mountain in the extreme northeastern part of the island. (Fig. 3.)

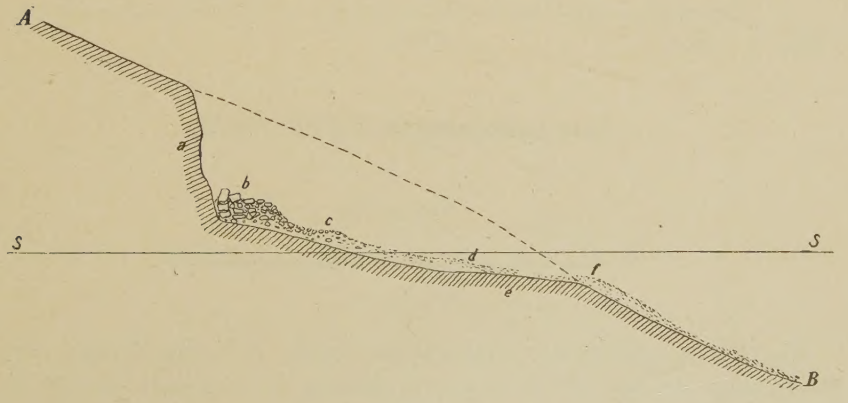
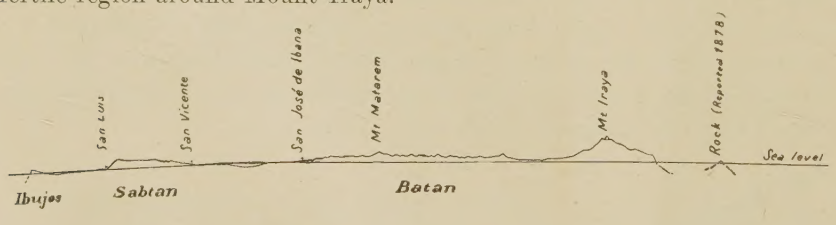


FIG. 3.

The cliffs of the Piedmont region are composed of stratified sandstone and conglomerate, poorly consolidated, and it is only the constant action of the surf that permits such loose material to form cliffs. The pebbles in the conglomerate beds are all of volcanic origin, and cross-bedding is common in the sand and gravel layers, but no distinct ripple markings appear. I found several pieces of wood embedded in various parts of the cliffs, but never any marine shells. All these facts go to show that the conglomerate is distinctly of terrestrial origin. However, northward from Santo Domingo to Diojo Point there is a series of cliffs of coral limestone interbedded with a distinctly marine conglomerate, the latter containing a large proportion of limestone pebbles. The relations between this limestone and the conglomerate just described, which forms the cliffs bounding the Piedmont area, is not entirely clear, but if the coral has grown upon the conglomerate, there may have been some slight reworking of the material by the waves. The extremely flat plain of Vergnung on the east coast opposite Santo Domingo seems to have been planed off by marine action, as rounded pebbles and shells are found on its surface. (See Pl. VI.) It is of course possible that the limestone area north of Santo Domingo may have been an earlier uplift against which the wash deposits from the mountains have been built up.

Santo Domingo de Basco, the capital of the subprovince and the largest town in the islands, owes its prominence entirely to its situation. It possesses the only harbor in the islands with a stretch of beach unobstructed by coral, where boats can be hauled up. It is surrounded by the best farming land and in addition it is the central point for the fertile region around Mount Iraya.

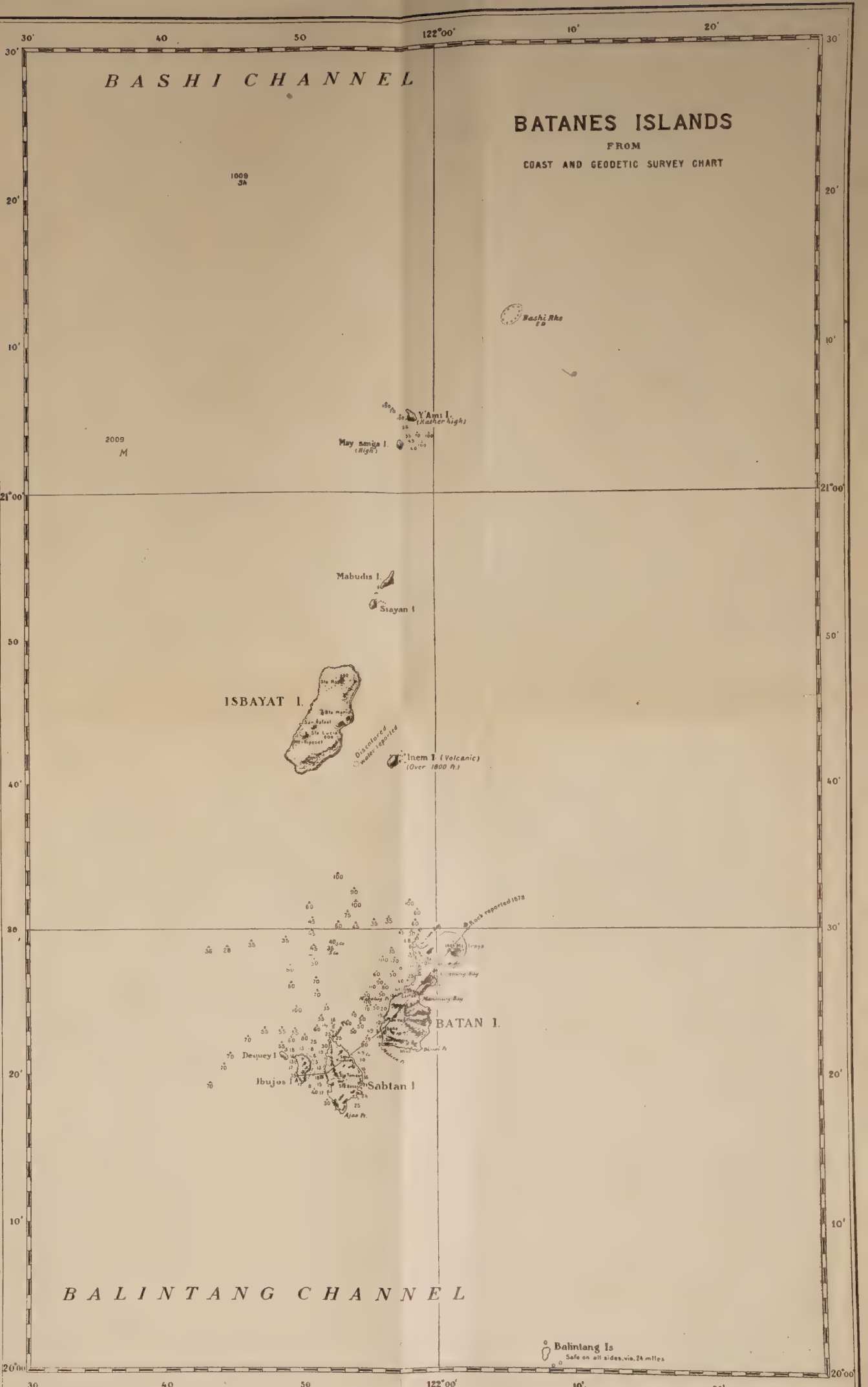


Cross Section along line A B C D (Plate II)

Scale 1/100,000

FIG. 4.

Fig. 4 is a cross section through the islands of Ibujos, Sabtan and Batan along the line ABCD of map 2, showing the principal features of the topography.


BASHI CHANNEL
BATANES ISLANDS
FROM
COAST AND GEODETIC SURVEY CHART
Bashi Rks
Y'Ami I.
(Rather high)
May Sanga I.
(High)
Mabudis I.
Siayan I
ISBAYAT I.
Inem I. (Volcanic)
(Over 1800 ft.)
Rock reported 1878
BATAN I.
Desuey I
Ibujos I
Sabtan I
BALINTANG CHANNEL
Balintang Is
Safe on all sides, via. 24 miles
30'
40'
50'
122°00'
10'
20'
21°00'
20°00'

Map No. 2.

INEM.

Inem Island, north of Batan, is noted on the chart as "volcanic" and the height is put at over 1,800 feet (550 meters). These two facts represent practically all the information I have been able to obtain concerning this rock. It is a lone rock rising out of the sea, with steep cliffs on every side, and dangerous currents make landing there practically impossible. As seen from the deck of the steamer it is an extinct volcano which has suffered heavily from marine erosion. Reports are current that steam has been observed to rise from its summit, but I am inclined to believe that the small clouds which often hang around the mountain are responsible for this belief.

THE SIAYANES.

The islands lying north of Isbayat are locally grouped together as the *Siayanes*, a word said to mean "good fishing grounds." However, the natives seldom venture north of Isbayat, as there is a strong northerly current which has more than once carried their boats to the Japanese island of Botel Tobago where they have suffered from the attacks of savages.[9] The islands of Siayan and Mabudis of the Siayanes Group, judging from what could be seen from the steamer, seem to be composed of lava flows with a small amount of limestone. Mabudis shows a sharp, irregular peak, possibly an extinct volcano above a fairly level terrace. (See Pl. VIII.) Both of these islands are largely cliff-bound and have probably been separated by marine erosion. North of these is another pair, Y'Ami and May sanga (or North Island). Y'Ami, on which I was able to land for a short time, is a small island of considerable height and, except for a few feet of coral near the shore is composed entirely of volcanic material. There is a considerable quantity of stratified and cross-bedded sandstone in the lower part, above this a volcanic agglomerate, consisting of basalt fragments and bombs. Interbedded with this are several flows of basalt. I did not have time to reach the top of the island and so could not determine whether or not it was a volcano, but from the apparent horizontality of the lava flows I did not consider it probable. The same flows seem to be continued on the neighboring island of May sanga, which is probably separated from Y'Ami by marine erosion. It seems likely that all four of the Siayanes islands, together with their outlying rocks and perhaps Inem and Batan, once formed a single land mass, built up by flows from Mabudis, or perhaps from Inem or even Iraya.

[9] Davidson, J. W.: Formosa, Past and Present (1903) mentions "Bashe" Islanders as being shipwrecked on Formosa and the Batanes people are now living on Botel Tobago.

THE LIMESTONE ISLANDS.

The three limestone islands lie to the westward of the rest of the Batanes and topographically are in marked contrast to them.

IBUJOS.

The island of Ibujos consists entirely of coral limestone rising in steep cliffs to a height of over 60 meters. These surround the island, except on the eastern side where the land rises gently from the fringe of sand dunes and small ponds around the shore, in contrast to the 300-meter agglomerate cliffs of the island of Sabtan less than 2 kilometers distant. (See Pl. IX.) The surface of Ibujos is gently rolling, but without any streams or definite stream valleys. This condition is partly due to the solubility of the rock which allows water to run off in underground channels, but it is also in large part an effect of the recent date of the uplift, which has not allowed sufficient time for the streams to form valleys. The soil seems to be volcanic ash rather than limestone.

DESQUEY.

Desquey, a little island to the west of Ibujos, is entirely cliff-bound and inaccessible, but otherwise seems to be exactly like Ibujos.

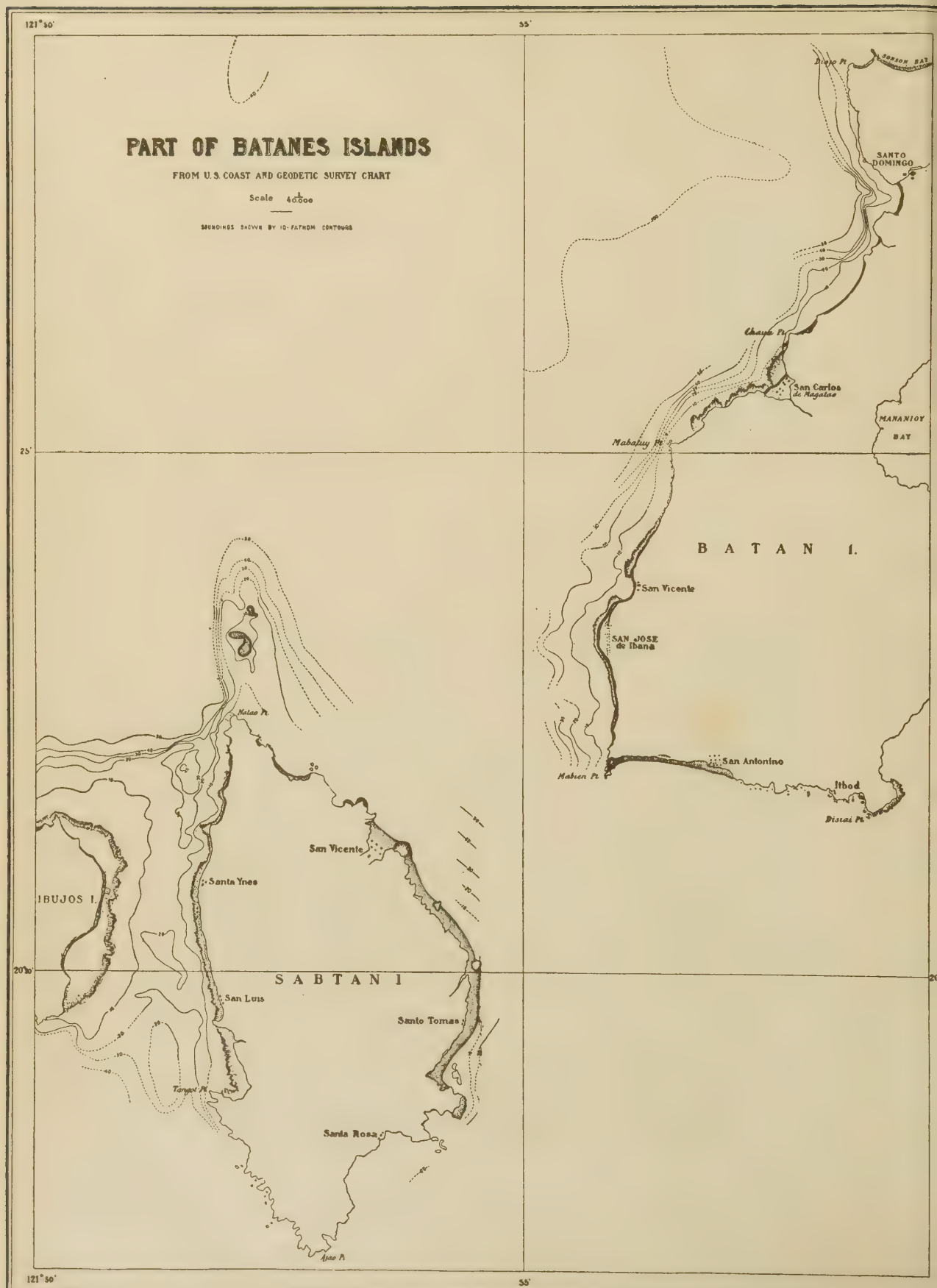
ISBAYAT.

Isbayat, the largest island of the group is likewise entirely surrounded by cliffs, the only landings being steps cut in the rock in one place, and a series of ladders in the other. From the deck of the steamer the cliffs seemed to be similar to the limestone cliff of Diojo Point on the north of Batan Island, and I am told by people who have visited the island that the land slopes downward from the top of the cliffs toward the villages which are situated in small "sinks." This fact inclines me to believe that Isbayat is formed of limestone, rather than that it is of volcanic origin. The island is said to be the most fertile of the group, but has a reputation for unhealthfulness, the natives of the other islands suffering from fever whenever they go there. Between Isbayat and Batan, and in a less degree throughout all the islands, there are extremely powerful and complex tidal currents which render the passage between the individuals of the group extremely dangerous, so that almost the only communication with the outside world is when an occasional steamer takes on a load of cattle from the Isbayat pastures.

SUBMARINE CONFIGURATION.

The soundings given on the chart are very few and these for the most part (see map No. 3) do not reach to bottom, but record "no bottom" at depths of from 25 to over 100 fathoms. However, meager as the information is, it will be of interest to examine it in some detail.

South of Botel Tobago there seems to be a bench of about 100 fathoms


121°50'
55'
PART OF BATANES ISLANDS
FROM U.S. COAST AND GEODETIC SURVEY CHART
Scale 40,000
SOUNDINGS SHOWN BY 10-FATHOM CONTOURS
Diayo Pt.
SABTANG BAY
SANTO DOMINGO
Chavis Pt.
San Carlos de Magatao
MANANIOY BAY
Mabatuy Pt.
25'
BATAN I.
San Vicente
SAN JOSE de Ibana
Matao Pt.
San Antonino
Mabsen Pt.
Itbod
Distai Pt.
San Vicente
Santa Ynes
IBUJOS I.
20°30'
SABTAN I
San Luis
Santo Tomas
Targot Pt.
Santa Rosa
Apao Pt.
121°50'
55'

in depth extending as far as Gadd Rock, about 31 kilometers south of the island of Little Botel Tobago, where it ends sharply in the deep Bashi Channel. Between Botel Tobago and Formosa, on the other hand, a depth of 1,050 fathoms (without bottom) is reached. From Formosa a similar ridge extends southwards for about 90 kilometers where a sounding of 73 fathoms is recorded, but beyond this there seems to be a marked deepening to the southward. The "position doubtful" Mark Lane Shoal in latitude 21° north, longitude 120° east may be a part of this same shelf. A line of deep soundings through the Bashi Channel gives the following depths: 2,645 fathoms, 55 kilometers east-northeast of Botel Tobago; 2,618 fathoms, 40 kilometers east of Little Botel Tobago; 1,287 fathoms, 27 kilometers east-southeast of Gadd Rock; 1,009 fathoms, midway between Gadd Rock and Y'Ami; 2,009 fathoms, 40 kilometers west of Y'Ami; 2,053 fathoms, the same distance west of Isbayat; 1,784 fathoms, 55 kilometers west-southwest of Isbayat, and 936 fathoms, 73 kilometers west-southwest of Desquey. These soundings seem to show the existence of a deep trough connecting the "deep" off the west coast of northern Luzon with that to the southeast of the Riukiu Islands.

On the American side of the Bashi Channel the soundings are those made by the British survey of 1845 and are for the most part "without bottom" and hence of less value for our purposes. No soundings are given in the vicinity of Isbayat and the Siayanes, except between Y'Ami and May sanga where there is a minimum depth of 36 fathoms, probably from tidal scour and recent depression.

Between Ibujos and Sabtan there are for some reason a great number of soundings, generally less than 20 fathoms. The most interesting feature of these is a narrow trough of from 19 to 45 fathoms depth close to the northern part of the west coast of Sabtan. Another feature is the sudden deepening beyond 20 fathoms, the 20- and 30-fathom countours being in most cases close together. There are very few soundings to bottom near Batan Island, but such as are given seem to indicate the existence of a 20-fathom shelf.

GEOLOGIC PROBLEMS.

Having given a general description of the islands it seems advisable briefly to touch on the chief geologic problems before proceeding to a physiographic discussion.

THE ORIGIN OF THE AGGLOMERATE.

The volcanic agglomerate, so far as we can see, is the basal rock of these northern islands. In thin sections of limestones which rest upon it, Mr. W. D. Smith has found the Miocene fossils *Orbitoides* and *Lithothamnium*, hence the agglomerate may be considered pre-Miocene. Thus, in accounting for its origin, hypotheses depending on existing physiographic forms, such as the explosive activity of Mount Iraya or

an explosion crater in the amphitheatral valley north of Itbod, are untenable. Mr. Smith [10] has discovered volcanic agglomerate of probably similar age in Ilocos Norte, hence a proper explanation should include both. The Babuyanes Islands have a roughly circular form and might be considered as a large explosion crater but for the fact that they, like the Batanes, are divided into an eastern volcanic group and a western group of coral islands, and as in addition no such agglomerate is found on Camiguin, the only island of the group which the writer has been able to visit. From present knowledge the most that can be said in regard to the origin of the agglomerate is that in pre-Miocene times enormous, explosive, volcanic activity between latitudes 18° 30′ and 21° north built up a land mass in the region of the Batanes Islands and a considerable mass of agglomerate in Ilocos Norte near Cape Bojeador. The northern part of Luzon eastward from the *Cordillera Central,* is as yet unexplored and hence it is impossible to say how great an area this agglomerate may cover.

FAULTING.

The difference in structure and topography between the neighboring islands of Sabtan and Ibujos is extremely striking, the former having on its western side a straight line of agglomerate cliffs, reaching an altitude of about 400 meters and broken only by narrow cañons, with the fall-line close to the sea, and the latter being composed entirely of limestone (age as yet undetermined) rising gradually on its eastern side toward the west. This striking difference of material and topography, together with the straight coast line of the western side of Sabtan and the trough just off the Sabtan shore, to say the least, strongly suggests a fault line between the two islands, with upthrow on the east. If we accept this fault on the evidence as given above and prolong it to the north and south we obtain some suggestive results. Extending the line northward in a direction N. 6° 35′ E., brings Isbayat (probably similar to Ibujos) to the west of the line and the Siayanes and Inem (neo-volcanic) on the eastern side. Following the same line to the southward there is a similar division of the Babuyanes Islands, the Balingtang rocks (probably volcanic), Babuyan Claro, Camiguin and the Didicas rocks all lying to the east of the line, and Calayan, Dalupiri and Fuga (Babuyan) to the west. This line further extended would meet Luzon at the mouth of the Cagayan River.

ALIGNMENT OF VOLCANOES.

The close alignment of both active and extinct volcanoes along the one hundred and twenty-second meridian is remarkable. The following are the longitudes: Y'Ami Island, 121° 58′; Mabudis Island, 121° 57′; Inem Island, 121° 57′; Mount Iraya, 122° 01′; Balintang Rocks, 122°

[10] Smith W. D.: *This Journal, Sec. A, Gen. Sci.* (1907), **2,** 153.

08′; Babuyan Claro, 121° 56′; Camiguin Volcano, 121° 52′; Didicas Volcano, 122° 09′, and Cagua Volcano, in northeastern Luzon, 122° 04′. It seems reasonable to infer from the close alignment of the volcanoes of the Babuyanes and Batanes groups and the supposed fault between Sabtan and Ibujos, that the volcanoes mark a fissure in the earth's crust and that their activity may be dependent upon sea water having had access to great depths along the fault.

CORRELATION.

There is not enough material at hand just now to enable us to determine the tectonic relations of the Batanes with Formosa and with the Babuyanes and northern Luzon. However, there are certain significant facts. First, the enormously deep Bashi Channel seems to trend in a northeasterly direction. If so, it may represent a geosyncline or trough, parallel to the tectonic lines shown by Von Richthofen along the southeast coasts of China and Cochin-China and to the northwest coasts of Borneo and Palawan. This deep channel prologed, would enter the 4,000+meter "deep" of the northwest coast of Luzon and follow the 2,000+meter "deep" to the southeast of the Riukiu Islands, hence, by inference, making the Philippines and Japan (including Formosa) separate geologic provinces. Professor Kôtô [11] sums up the present geological knowledge of Botel Tobago (Kôtô) as follows:

"Fringing reefs are said to skirt the shore, some portion attaining double man's height above the water's edge, indicative of a recent negative shift of the relative levels. It seems to me probable that they are not the reefs of Neocene time, which usually attain a considerable height of more than 200 meters as in the Apes Hill of Takao, but those of a comparatively recent date, possibly representing a *diluvial formation*. The plateau-like elevation, which faces the sea in cliffs, seems in parts at least in the northeast point to consist of volcanic agglomerate. A greater part of the interior seems to be built of volcanic rocks with a gabbro-like plutonic mass as the foundation of the island exposed at the west coast, but their mutual relations and area of distribution are quite unknown to me."

Professor Kôtô also gives petrographic descriptions of feldspar basalts, hornblende andesites, apoandesites, gabbro and serpentine from Botel Tobago.

Thus, the existence of a volcanic island in longitude 121° 30′, although across the Bashi Channel from the Batanes and the great Taito furrow running N. 20° E. from the southern point of the island,[12] together with the Taito Range just to the east of it, may be more than mere coincidences.

The chain of volcanoes is certainly significant in regard to the relation of the Batanes Islands to the Babuyanes and northern Luzon, as is also the separation of the limestone islands of the groups from the volcanic ones.

[11] *J. of the Coll. of Sci. Tokyo* (1900), **13**, 46.
[12] Hobbs, W. H.: *Am. Geol.* (1904), **24**, 374.

Furthermore, the earthquake records seem to show a closer connection between the Batanes Islands and the northeast of Luzon than with the northwest.[13] However, these points of tectonic geology will be discussed more fully in a subsequent paper.

PHYSIOGRAPHY.

FORMATION OF THE LAND.

The first geologic action of which we have any definite record is the building up of the agglomerate, by explosions from somewhere to the southward. At a moderate estimate the agglomerate formation has a volume above sea level of between $1\frac{1}{2}$ and 2 cubic miles, and the amount of erosion undergone by the islands shows that this figure represents a small fraction of the original volumes. That the agglomerate was not built up in a single explosion is shown by the areas of stratified sandstone and conglomerate which occur here and there throughout the formation, showing that there were periods of quiescence of sufficient length to allow streams to work during this period. Nothing can be said concerning the region in which the explosions took place except that it was of volcanic formation, for only lava pebbles are found in the agglomerate and this lava is practically all andesitic.

THE SABTAN UPLAND.

The first record of the physiographic cycle is found in the upland of Sabtan. This belt from 300 to 400 meters above the sea shows a topography which if not that of a peneplain, is at least in advanced "old age" and represents the cycle previous to the present. It is of pre-Miocene age, since Miocene limestones are found on the eastern flanks of the plateau. We have then at the commencement of the latest physiographic cycle in pre-Miocene time, a low-lying land mass without marked relief covering at least the area at present occupied by the islands of Desquey, Ibujos, Isbayat, Sabtan, and Batan.

PERIOD OF UPLIFT AND EROSION.

The next chapter in the history was one of uplift, accompanied by pauses in which the limestone terraces of Batan and Sabtan were formed, and possibly by some oscillation. However, this uplift was too rapid for the streams to keep up with it and the present topography of the agglomerate area is characteristically "young," most of the streams flowing through typical box cañons.

A peculiar feature in the drainage conditions of Batan is the amphitheatral valley north of Itbod. This is a wide, open valley of irregular, ellipsoidal shape, inclosed between ridges of agglomerate and cut up

[13] Maso, Rev. M. Saderra, S. J.: Philippine Census (1905), 1, 246.

by spurs running out from these ridges. The streams here have gentle gradients and gently sloping banks. In the central part of this valley outcrops of andesite are found, one of which shows a wide zone of pyritized attrition clay, with a northwesterly strike, the result of faulting.

The two streams draining this valley flow to the southward, cutting through the Matarem range which here runs east to west, in steep cañons, uniting at the barrio of Itbod. The eastern of these two streams can be followed from Itbod to within a short distance of the point where the broad valley begins. It flows through a very narrow gorge generally less than fifteen meters in width, with walls over sixty meters in height. Waterfalls are frequent.

There is no reason why the valley should not be readily explainable by superimposed drainage. The presence of a fault the strike of which is parallel to the long axis of the valley is probably sufficient to account for this. A shattered fault zone would readily yield to erosion and be worn down to the grade determined by the rate of cutting of the stream through the well cemented material to the south. Hence, the part of the stream and its tributaries in the region of the fault zone would be practically at grade, only cutting down the valleys as the deepening of the cañon gave them new power. Thus, there is a gradual "sinking down" and preservation of mature topography from a previous cycle in a present extremely youthful stage. It seems strange that the stream draining the valley should not flow along the line of the faulting to the southeast, where the hills are lower, instead of directly through the highest part of the ridge. As it does not, there is evidence that the drainage conditions which existed before the uplift began, are now superimposed upon the younger topography. Eventually, if conditions remain unchanged a stream working up along the fault zone from the southeast will capture the headwaters of the present streams. It may already have done so in part, but without a topographic map the dense vegetation makes it impossible to secure any grasp of the details of the physiography. The two streams which at present drain the valley are also engaged in a struggle for supremacy. The eastern of these, having the shorter course, can make steeper grades and hence will eventually have the advantage, but at present this seems partly neutralized by the otherwise more favorable situation of the western one, which receives the drainage from the Matarem Range. However, it seems probable that the eastern stream has already captured an eastern branch from its neighbor.

A peculiar feature of drainage conditions in general is the small amount of work accomplished by the streams in a region of such heavy rainfall. The older topography of Sabtan is of pre-Miocene age and is at an elevation of over 300 meters, hence it seems strange that any of it, far less such a large belt, should still exist. One reason for this condition is undoubtedly the smaller drainage basins of these islands as

compared with mainland conditions. The erosive power of streams is dependent very largely upon the size of their drainage area. The one of two streams receiving more water because it has a larger drainage area, has the advantage over one with a slightly better grade, but a smaller drainage area. Hence, we must not look for the same proportion of work of stream erosion on small islands as would be found on Luzon. However, another point to be considered here, is that the present strip of Sabtan upland is bounded on the west by a fault scarp and that the western streams have scarcely begun their work.

SINKING OF IBUJOS-DESQUEY.

The sinking of the land to the west of Sabtan must have taken place toward the end of the uplift, for the western coast of Sabtan shows no traces of terraces or other evidence of having been submerged. Probably the period of greatest movement was contemporaneous with that of greatest activity among the volcanoes to the east of the line of faulting. Movement along this line is in all likelihold still progressing. This is indicated by the prevalence of earthquakes in the Batanes, where the records for 1906 show eleven shocks, as against three at the mouth of the Cagayan River (Aparri) and on the northwest coast of Luzon (Vigan).[14] In five years (presumably 1898–1902) only twenty-five earthquakes were recorded in the southern part of Formosa (Taiku).[15]

The downthrow of the western part of the older plateau could not have depressed the land to a point below that at which coral can grow (100 fathoms). Coral, formed upon this depressed shelf and later elevation affecting both sides of the fault, with perhaps some reverse movement of the fault blocks, has brought the western islands, Ibujos, Desquey and Isbayat to their present elevation.

DEPRESSION.

It is not to be supposed that the period of uplift was uninterrupted. The benches which give us our evidence of elevation are in themselves indications of stationary periods and hence it is not improbable that, although uplift has been the dominant feature of the history of the islands, there also may have been small periods of depression or tilting. The persistence of the 20-fathon shelf around Sabtan and Batan and the submarine contours of Santo Domingo Bay (Map No. 3) may indicate a depression. On the other hand, this 20-fathom shelf may be indicative of the amount of marine erosion accomplished during the time that the islands have remained at their present level, showing the depth to which wave action is effective in the region. The islands, as has already been stated, lie in the track of the majority of the typhoons, hence

[14] Algue, J.: Monthly Bulletins of the Observatory, Manila, 1906.
[15] Davidson, J. W.: Formosa, Past and Present (1903.)

marine erosion must be a very significant feature. It is to be regretted that there are no soundings on the Pacific side of Batan, as it would tend to clear up this point if we knew whether this submarine shelf were deepest on that side. Naturally, where open to the Pacific, the waves would have greater force than on the western side, hence it is to be expected that if the typhoon waves of the China Sea are effective to a depth of 20 fathoms, those of the Pacific should cut a deeper bench.

MARINE EROSION.

In all probability Ibujos and Desquey were one island within recent geological time, as was the case with Siayan and Mabudis and also Y'Ami and May sanga. It is not improbable that Isbayat may have been separated from the other limestone islands by marine erosion, and that the four Siayanes Islands may at one time have formed one island. If this is so, then the amount of land lost through marine erosion must nearly equal the present area of the islands.

The land, at least Batan Island at the present time, is essentially stationary. This is shown by the high sea cliffs of unconsolidated material around Mount Iraya. A sea cliff represents the shoreward limit of effective action of storm waves. The action of waves upon the coast, in addition to the formation of a cliff, tends to build out a submarine shelf, partly through cutting away the land and to a less degree by depositing the material carried out by the undertow. The relation of this shelf to a receding cliff must always be such that the shelf must be kept worn down to such a depth by the abrasive action of material carried out by the undertow, that the waves will be able to do effective work against the cliffs. The analogy to stream conditions is very close. Under normal, stationary conditions of the land the undertow near the coast acts in time of storm as a degrading stream, the force of the waves hurling pebbles against the face of the cliff, loosens great blocks which are later broken up to a size suitable for transportation. These are carried seawards by the undertow which has sufficient force to keep the wearing down of the beach and shelf in such relation to the point where the waves are tripped, that the latter are able to do their most effective work on the cliff and to keep the undertow constantly supplied with new material. When the undertow reaches deeper water it necessarily has less velocity and consequently less carrying power. The material borne out is therefore deposited, the coarser nearer shore and the finer farther out, just as a stream degrading near its head deposits its material when its velocity and carrying power become less. Since the carrying power of the undertow varies as the 3/2 power of its volume and the sixth power of its velocity,[16] it is clear that only during times

[16] Gilbert, G. K.: *U. S. G. S. 5th An. Rep.* (1884), 89.

of storms is it as effective as a degrading stream. Marine erosion may be tremendously effective during the progress of a tropical cyclone. This is shown by the fact that in the vortex of the typhoon the elevation of the water level, due solely to decrease in pressure of the atmosphere, may amount to nearly a meter.[17] A long period without storms has the same effect on coastal erosion as a similar one without floods has upon stream erosion. The waves, having less force, are no longer as effective upon the cliffs and the weaker undertow is compelled to deposit its material nearer shore, building up an additional bench of loose detritus which is carried away by the next storm, just as the deposits made by a stream of small transporting power are carried away in times of flood. When elevation of the land occurs, no matter how small, the delicate relation between bench and cliff is destroyed, waves are tripped before they can do effective work upon the cliff and the result is first, a protecting reef which must be planed down before the cliff can again be attacked, and, if elevation continues, a raised bench. If, on the other hand the land is depressed, the waves beat directly upon the cliff. In the deeper water the undertow is less effective as a transporting agent and must deposit the material fed to it by the waves until it has built up its bench to "grade."

The material deposited by the undertow at the end of the bench comes into the power of the shore current. The action of this current is extremely variable, depending upon the prevalence of onshore winds and the shape of the coast line. Its action is always to simplify the coast line by depositing its load in and across the deeper reëntrants. On the coast of Batan this current should be strong during the prevalence of steady monsoon winds, although it is complicated by and subordinate to the tidal currents. Fig. 3 (p. 9) modified from Gilbert,[18] illustrates the formation of a sea cliff, on a coast having an original outline of AB. Beginning with the sea cliff (*a*) in this diagram, we have first, an upper bench (*b*) composed of large blocks broken off from the cliff and of slightly rounded bowlders. This is only reached by the waves of the heaviest storms. Below this bench there is another ledge (*c*) the material of which is worked over by waves of ordinary storms and is consequently composed of smaller bowlders. Beyond this is the beach (*d*) of material progressively smaller towards the sea. This beach is being gradually built up in ordinary weather, but in time of storm it is moved by the undertow which erodes the ledge (*e*), to a point where the waves when breaking do their most effective work on the cliff. Farther seaward at (*f*) is the extension of the terrace built by the storm undertow;

[17] Algue, Rev. J., S. J.: The Cyclones of the Far East. Weather Bureau, Manila (1904), 173.

[18] *Loc. cit.*, 84.

the extent of this at any given point depends upon the strength of the shore current at that point. The features (*c*) and (*d*) belong to periods of moderate weather and hence are constantly being destroyed and rebuilt.

It is clear in the case of the cliffs of poorly consolidated conglomerate surrounding the northern part of Batan, that they could not retain their present form without constant cutting by the waves. Hence, the land can not be rising, for otherwise the elevation of the bench would cause the waves to trip before reaching the cliff, and the cliff, left to the disintegrating action of the atmosphere and ground waters, would slump down until the angle of rest of its material is reached. On the west coast of Isbayat there is a considerable depth of water very near the shore and there is no beach between the cliffs and the sea. This indicates recent depression.

TIDAL SCOUR.

The tidal scour is another marine agency which must have considerable effect. The tidal wave between the Pacific and the China Sea must pass through the Bashi and Balingtang channels. Consequently, the wave is narrowed, its force increased and an extremely complex series of strong tidal currents is created throughout the islands. It is to be expected that these currents should have some effect upon the submarine configuration and it seems likely that the channel of Santo Domingo Bay and that between Sabtan and Ibujos while possibly of terrestrial origin, owe their present depth and preservation to tidal scour. The depth at present of the channel between Y'Ami and May sanga is undoubtedly due to the tide.

CORAL.

The upbuilding accomplished by the coral is opposite to the destructive agencies of waves and tide. There are few coral reefs in the more exposed portions of the islands, such as the northern and eastern coast of Batan, but growing coral is found everywhere in the more sheltered portions. Beginning on the north side of Santo Domingo Bay there is a series of small coral reefs extending along the west and south shores of Batan as far as Disiai Point. There is only a small amount of coral growing in Santo Domingo Bay, probably because of the sediment brought down by the stream from Mount Iraya; the reef is also broken by small channels, due to streams, which determine the position of the barrios of San Carlos de Magatao, San Vicente, San Jose de Ibana, San Antonino and Itbod. Besides this the points of Chaua, Mabatuy and Mabien stand out beyond the reef. The reef on Sabtan is more extensive, forming a barrier around the island which is broken only by small channels at San Vicente, Santa Rosa and Santa Inés, and at Natao and Ajao Points. There is no inlet at the barrio of San Luis, making it necessary to launch

the boats across the reef at high tide, often a dangerous proceeding. However, the barrier reef reaches its greatest development on the eastern shore of Ibujos; there it has a width of nearly a kilometer, and is unbroken by any inlets. On the west shore there is no coral and the limestone cliffs sink sharply into deep water. The same is true of the cliff-bound island of Desquey.

VULCANISM.

Volcanic activity may be regarded as a physiographic accident, interfering with, but independent of the normal cycle of uplift, erosion and ultimate peneplanation. In the history of the Batanes, vulcanism has played an important part. The islands themselves owe their origin to volcanic outbursts of some kind and volcanic activity has been a factor in all stages of their history. There seem to have been periods of lava eruption during the time that explosive outbursts were building up the agglomerate mass. This is shown by the andesite of Natao Point, which may be a flow. The lavas which have extended from the Batanes volcanoes are all basic, consisting of andesites and basalts, and although no general series can be made out, the more recent of them seem to be the more basic.

Volcanic activity during the period of pre-Miocene degradation, is shown by the dikes which cut through the agglomerate, particularly near Ajao Point in Sabtan. During the time of uplift, the *locus* of volcanic action seems to have shifted to the east and north, building up the Siayanes, Inem and Iraya. Activity gradually died out, first at the north, and now the only volcano of a chain of three and possibly four which retains its symmetrical form is Mount Iraya, with its double (or triple) crater indicating long periods of quiescence between those of activity. The present interval of quiescence has lasted so long that the volcano has passed through the solfataric and hot-spring stage, the center of activity having shifted still farther to the southward, to the Babuyanes Islands. The history of the Batanes Islands may be looked upon as a constant struggle of the land for its existence, with vulcanism and coral reef-building in opposition to marine, and to a less degree, stream erosion, uplift and depression being the factors really controlling the struggle.

HUMAN RESPONSE TO PHYSIOGRAPHIC CONDITIONS.

The natives of Batan and Sabtan were divided into three warring clans whose boundaries depended upon topographic features before the coming of the Spaniards and the abandonment of their savage life. In Sabtan, where communication is easy on the east coast, the people were united under one chief. Batan, on the other hand, having a natural barrier in the range running west from Mabatuy point was divided into two clans. The earlier village-forts were naturally built upon commanding eminences,

but with the abandonment of tribal warfare defense was no longer a consideration and the sites were selected first, where gaps in the reefs allowed water communication and second, with respect to the amount of arable land in the vicinity.

The region around Santo Domingo owes its superior agricultural advantages to the piedmont deposit of gravel and fine volcanic material from Mount Iraya. Rocks weather to form the same kind of soil in the agglomerate regions of the island, but there the topography, marked by a series of ridges and cañons, makes conditions unfavorable.

In this connection it may be well to note a point of danger to much of the arable land of the Batanes. A large proportion of the cultivated fields is upon steep hillsides, and the trees have been entirely cut away from the ridges. The result is a gradual creeping down of the soil toward the sea. In some places this has gone so far that large cracks have been formed, which follow the ridges for considerable distances. Unless some reforesting is done along the tops of these ridges to hold the soil, much valuable land will be lost. On the sides of the valley just north of Santo Domingo, hedges around the fields seem to have held the soil sufficiently to prevent cracks from forming.

The natives of Batan and Sabtan owing to their isolation have become a race of excellent seamen and boat builders, in comparison with the slovenly seamenship and low constructive ability of the Ilocanos of northern Luzon. Their small boats, or *tatayas,* built somewhat after the fashion of a dory, are excellent surfboats and quick to answer the helm. They make frequent trips to Aparri in their large boats, built somewhat like a Chinese junk, and sometimes they even sail as far as Manila to sell their hogs and cattle. These larger boats are built and owned by the communities. A knowledge of the intricate tidal currents plays so great a part in the life of the people that the best pilots are the most important men of the community.

The natives of Isbayat, being more completely isolated through poorer facilities for communication, have retained more independent characteristics, such as their own language and their peculiar art of basket making. This island owing to its reputation for unhealthfulness, receives no immigrants and is consequently underpopulated and largely given over to pasture land.

SUMMARY.

In pre-Miocene times a land mass of considerable extent was built up by enormous explosive eruptions from unknown sources and, after the cessation of these explosions, was gradually worn down by streams to an extremely mature topography.

The next stage, from the Miocene to recent times, was one of predominant uplift, limestone containing Miocene fossils being found at elevations up to 275 meters. This period was marked by renewed activity

of the streams and the cutting of steep cañons. The *locus* of volcanic activity is now shifted from the region of Sabtan to a line along the one hundred and twenty-second meridian.

Faulting between Ibujos and Sabtan cut off part of the old upland, leaving a well-marked fault scarp along the west coast of Sabtan and growth of coral and later elevation brought a limestone mass, of which the islands of Isbayat, Ibujos and Desquey are remnants, to the surface. It seems probable that this fault extends southward through the Babuyanes group and it is possible that the Cagayan valley may represent its continuation in Luzon. The large number of earthquakes recorded in the Batanes indicate that movement along this fault is still going on.

The recent history of the Batanes Islands is mainly one of lessening of the area. The land appears to be stationary and nothing is gained through uplift. The upbuilding force of vulcanism has ceased, leaving the growth of coral reefs the only force acting in opposition to the erosive action of the waves, streams and tides. The work of man in deforesting the ridges is assisting in the wearing down of the land.

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NEW AND LITTLE-KNOWN LEPIDOPTERA OF THE PHILIPPINE ISLANDS.

By W. Schultze.

(From the Entomological Section, Biological Laboratory, Bureau of Science, Manila, P. I.)

RHOPHALOCERA.

NYMPHALIDÆ.

Elymniinæ.

ELYMNIAS, Hübn., Verz. bek. Schmetterl. (1816), 37.

Elymnias palmifolia sp. nov. (Pl. I, fig. 1).

♂, fore wing, dark brown with a decided blue iridescence. A large, subapical, white spot, divided into 3 parts by the veins. An elongated streak between first and second median veins, slight traces of two other elongated submarginal streaks. Hind wing; pale brown near costal and inner margins, darker towards the outer margin. Between the veins, 7 yellowish-white stripes, of which there are 2 between median veins I and II. These stripes run nearly to the base of the wing where they suffuse with the general color, but they are very pronounced towards the margin. Near the outer margin, slight traces of light, wavy spots, shining through from the under side. Marginal series of interrupted, crescent-shaped, white spots in pairs between veins and confluent with cilia. Under side of wings lighter; spots corresponding as to position, but differing in size from those above. Posterior to the subapical spot, a very small white one, the streak between median veins, I and II larger than above. Between submedian and first median veins, a broad, whitish streak having a darker one through its middle and showing traces above. On the hind wing the stripes are shorter than above. On the marginal area many irregular, transverse, wavy spots.

Length of wing, ♂: 39 millimeters.

Length of wing, ♀: unknown.

Tuguegarao, Cagayan, P. I.

Time of capture: July, 1905. (Warren Williamson, collector.)

Type ♂, No. 4604, in Entomological Collection, Bureau of Science, Manila, P. I.

This species is very closely related to *Elymnias malis,* described by Semper,[1] but as he says "The observation that neither the presence nor the size of a spot, but the arrangement of the individual spots, if present, is very constant in the different species of the genera Elymnias," I feel safe in describing this species as new.

HETEROCERA.

SESIIDÆ.

ADIXOA, Hamps., Fauna of Br. Ind. Moths (1892), 1, 198.

Adixoa tomentosa sp. nov. (Pl. I, figs. 2a male, 2b female, 2c 2d, cocoons with pupal skin.)

♀, head dark, violet-brown, front steel-blue, white at the sides; palpi white, sides blackish. Collar steel-blue, bordered in front by yellow. Thorax black with a few brownish scales and a violet sheen; a yellow stripe on the inner margin of tegulæ. Metathorax yellow; abdomen bluish-violet-black, rear margins of the second, fourth and anal segments yellow, the last slightly lighter. Posterior margin of other segments gray-brown, with a few ochraceous scales. Below, on the first abdominal segment, a white triangular spot; posterior margins white. Anal tuft black, with gray and whitish hairs, below lighter. Legs below whitish. Fore-wing, dark, iridescent, violet-brown with 1 hyaline streak in the cell, 4 beyond it, and 1 below. Discocellular yellowish, below the cell towards the base also somewhat yellowish. Cilia with a few ochraceous scales. Hind-wing hyaline, outer border with the color of the fore-wing; external cilia the same, those of the inner margin lighter to white, discocellular yellowish and brown.

♂, palpi yellow, blackish at the sides, front white, yellowish-brown on top. Posterior margin of second, fourth and anal segment yellowish. In the male, the anal tuft below is yellowish-white.

Length of wing, ♂: 8.5 millimeters.

Length of wing, ♀: 11 millimeters.

Manila, P. I.

Time of capture: June, 1905. (W. Schultze, collector.)

Type, No. 3345, in Entomological Collection, Bureau of Science, Manila, P. I.

The caterpillars live in a vine, *Paederia tomentosa* Blume, where they are easily found because of the swellings or nodules which they produce on the stems of the plant. The caterpillar makes a blackish, parchment-like cocoon compressed at both ends; from three to five cocoons are usually found together in a single nodule.

[1] Semper. Reisen im Arch. d. Phil. Die Schmetterl. d. Phil. Inseln. (1892), 5, 63.

SYNTOMIDÆ.

CERYX;[2] Wllgrn. Wien. Ent. Mon. (1863), 7, 140.

Ceryx macgregori sp. nov. (Pl. I, fig. 7).

♀, dark brown, antennæ white at tips, frons with a dark spot in the center. Tops and sides of head whitish. Collar with a yellow spot at the sides. Tegulæ with a yellowish spot at the base. A yellowish, median streak on pro-, meso- and metathorax. Abdomen dark brown with 4 longitudinal series of ochraceous spots on dorsum, ventrum and sides respectively; last 2 segments without spots and lighter. Fore-wing with 5 hyaline spots, a small, elongated antemedial, 2 medial and 2 postmedial, which have a bluish sheen in certain lights. The upper medial spot is in the cell and the lower postmedial one is divided by the dark vein. Hind-wing with a large hyaline spot from the base below the cell to vein IV. Legs dark brown, coxæ with yellowish spot.

Length of wing, ♂: unknown.

Length of wing, ♀: 12 millimeters.

Montalban, Rizal, P. I.

Time of capture: February, 1906. (Charles S. Banks, collector.)

Type ♀, No. 5189, in Entomological Collection, Bureau of Science, Manila, P. I.

I take pleasure in naming this species after Mr. R. C. McGregor, ornithologist of this Bureau, who has added a large number of insects to our collection.

EUCHROMIA, Hübner, Verz. bek. Schmetterl. (1818), 121.

Euchromia elegantissima Wllgr. Eugenies Resa omkr. Jordan (1861), 360.
Var. **diffusihelvola** var. nov. (Pl. I, fig. 3).

Colors of body and markings of the wings as in the regular form of *elegantissima*. The general color of the fore-wing is brownish irrorated with yellowish scales, especially near the outer margin. Cilia dark brown.

Length of wing, ♂: 22.5 millimeters.

Length of wing, ♀: 22.5 millimeters.

Manila, P. I.

Time of capture: December, 1903. (W. Schultze, collector.)

Types ♂ and ♀, No. 448, in Entomological Collection, Bureau of Science, Manila, P. I.

ARBELIDÆ.

SQUAMICAPILLA gen. nov.

Proboscis absent; palpi very minute and porrect; antennæ of the male short, bipectinated to the tips; legs covered with long hairs, which at the tips are scale-like and on the tibiæ of the fore and hind legs very prominent. Male with a long anal tuft of hair scales.

Type: *S. arenata.*

[2] Hampson: Cat. Lept. Phalaenae, (1898), 1, 40 (Syntomoides).

In the classification I place this new genus after the following: Arbela,[3] Moore, P. Z. S. (1879), 411.

Squamicapilla arenata sp. nov. (Pl. I, fig. 4.)

♂, palpi pale brownish; head white; collar in front whitish, at the sides dark brown. Thorax; posterior margin of tegulæ tufted with dark brown hair-scales, as is also the metathorax. Abdomen whitish; tuft of brown scales above the first segment; at the sides of the abdomen tufts of pale, yellowish hairs, the last segments (irrorated) with a few brown scales. Anal tuft very long, with its hair scales ochraceous white, but dark brown at the tips. Fore-wing pale ochraceous white, irrorated with a few brownish scales; traces of an antemedial band. At the base of the wing, below the cell, an irregular, dark brown spot and behind the cell another large, brown, trapezoidal one, sharply pronounced. Cilia with an interrupted line of brownish scales. The large scales of the fore-wing are very roughly arranged, giving the wing the appearance of being sprinkled with sand. Hind-wing white; inner margin with white hairs. Cilia broad, with traces of darker scales, as on fore-wing. Under side of the wings whitish.

Length of wing, ♂: 17 millimeters.

Length of wing, ♀: unknown.

Manila, P. I.

Time of capture: May, 1905. (Charles S. Banks, collector.)

Type, ♂, No. 2812, in Entomological Collection, Bureau of Science, Manila, P. I.

ARCTIIDÆ.

Arctiinæ.

PERICALLIA, Hübn., Verz. bek. Schmetterl. (1827), 182.

Pericallia integra Wlk. (Pl. I, fig. 5.)

♀, head, collar and thorax brownish-black; vertex of head yellowish-white, on top of head a dark brown spot, sides of collar and tegulæ yellowish-white. Abdomen orange above, with a blackish band on each segment, except the 2 posterior, which are black with an orange spot at the sides; abdomen below, dark brown. Fore-wing dark brown, a yellow-white band from base and below the cell nearly straight to vein II, then oblique to apex. Hind-wing orange, costal and outer margin at the apex dark brown, conjoined at middle and at the apex to larger spots; two dark brown spots at the posterior margin between veins I and IV; cilia brown, except an inner margin.

Length of wing, ♀: 20 millimeters.

Length of wing, ♂: 15 millimeters.

[3] Hampson: Fauna of Br. Ind., Moths. (1892), 1, 315.

Quingan, Nueva Vizcaya, P. I.

Time of capture: April, 1905. (Warren Williamson, collector.)

Type ♀, No. 3986, in Entomological Collection, Bureau of Science, Manila, P. I.

The male of this species is well known and Hampson [4] gives a good description of it as does also Semper.[5] Only the female is new.

Lithosiinæ.

DEILEMERA, Hübn. Verz. bek. Schmetterl. (1818), 178.

Deilemera browni sp. nov. (Pl. I, fig. 6.)

♀, palpi yellowish-white, third joint brown, second brown at the sides only. Head, thorax and abdomen light yellowish, the latter slightly darker. Head with black spots on front and vertex; 2 black spots on the collar, 4 on the tegulæ and 3 on the thorax. Abdomen above with black segmental bands, laterally with 2 rows of black spots. Fore-wing creamy white. A brown, elongated, triangular area extending from the base along three-fifths of the costa. Another brown area from the base along the inner margin to the lower angle then bending upward, not quite reaching the lower angle of the cell, running along the same and bending at vein II downward towards the base, but meeting vein I shortly before the base. Outer area brown, with its inner edges dentate between the veins. The white, inner area forms roughly the letter T. Hind-wing white, with a brown streak along the costa and a very irregular band along the margins except the base of the inner margin. Below, along the inner margin from the base, a small, brownish streak.

Length of wing, ♀: 25.5 millimeters.

Length of wing, ♂: unknown.

Manila, P. I.

Time of capture: ? (Rev. Robert Brown, S. J., collector.)

Type loaned, as No. 219 (Brown Collection), to the Entomological Collection, Bureau of Science, Manila, P. I.

I take pleasure in naming this species in honor of its collector, Rev. Robert Brown, S. J.

NOCTUIDÆ.

Quadrifinæ.

POLYDESMA, Boised Faun. Ent. Madag., Lep. (1833), 108.

Polydesma opala Pagents. Die Lep. Fauna des Bism. Archipels, (1900), 99.

♀, palpi grayish-white with a dark brown streak at the sides and a spot on the last joint. Head, thorax and abdomen grayish-white; a few darker scales in the middle of thorax; anal tuft reddish-brown. Fore and mid-tarsi and hind tibiæ and tarsi with dark brown spots. Fore-wing; basal

[4] Hampson: Cat. of the Lept. Phal. (1901), 3, 359.

[5] Semper, Reisen auf den Phil., Die Schm. d. Phil. Inseln (1892), 6, 486.

area grayish-white, reaching at the inner margin from the base to lower outer angle, then from the angle an oblique irregular line to the middle of costa. A large, irregular triangular suffused dark brown spot at the base and upper angle of the wing along the costa. Outer area of the wing suffused brown, a large white apical and a smaller, indistinct subapical spot. Below the apical spot another dark brown one; traces of indistinct dark brown and whitish, submarginal, zigzag lines. Cilia at the apex whitish, then pale brown with darker spots, and again at the inner margin whitish. Hind-wing fuscous, especially near outer margin, with an indistinct postmedial and submarginal band. A small, iridescent streak along the inner margin. Color of the cilia the same as on fore-wing but lighter. Below; fore-wing, suffused fuscous with traces of a postmedial and submarginal band; hind-wing with a dark spot at the end of the cell and the postmedial and submarginal bands more distinct as above.

♂; collar more ochraceous, thorax with dark, grayish-brown hairs. Fore-wing; the brown basal spot not so dark as in the female, with a whitish marking inside of it and its outer edges continued with a suffused, dark brown, irregular, antemedial band. The white area very much suffused with traces of brownish spots. The white, apical and dark brown, subapical spots prominent.

Only the male of this species is new.

Length of wing, ♂: 15 millimeters.

Length of wing, ♀: 15.5 millimeters.

Manila, P. I.

Time of capture: August, 1904. (Charles S. Banks and Rev. Robert Brown, S. J., collectors.)

Type ♂, No. 5711, in Entomological Collection, Bureau of Science, Manila, P. I.

REMEGIA,[6] Guen. Noct. (1852), iii, 312.

Remigia intextilia sp. nov. (Pl. I, fig. 8.)

♂, head, thorax and abdomen gray-brown, some dark speckles at the tegulæ. General color of the wings light gray-brown; fore-wing with 2 dark spots in the cell and a large prominent one at the end of it. Three very indistinct, dark, antemedial zigzag lines and a medial line from below the cell to the inner margin. A broad, irregular, slate-gray, postmedial band from the apex reaching the inner margin before the angle. An indistinct, white marking at the apex and a submarginal series of dark specks. Hind-wing with distinct, antemedial band nearly straight, suffused, indistinct, medial bands which are combined with the irregular, postmedial band. Some blackish specks at the medial line and a series of submarginal specks as on the fore-wing. The hair fringe at the

[6] Hampson: Fauna of Br. Ind., Moths (1892), 2, 527, Sec. III (Remigia).

inner margin pale. On both wings a fine, pale, marginal line. Under side of the wings, the markings are more distinct; fore-wing with a black spot in the cell and one at the end of it. A distinct medial line and postmedial band. Hind-wing with a dark spot near the base, an antemedial, distinct medial and a postmedial, zigzag line. The area between medial and postmedial lines is darker, forming a band.

Length of wing, ♂: 24 millimeters.

Length of wing, ♀: unknown.

Manila, P. I.

Time of capture: December, 1905. (Charles S. Banks, collector.)

Type ♂, No. 4808, in Entomological Collection, Bureau of Science, Manila, P. I.

CRUSISETA gen. nov.

♂, palpi with the second joint thickened and reaching vertex of head, the third short and blunt; antennæ bipectinated, the pectinations short. Thorax clothed with long hairs. Abdomen slender, dorsally with hair tufts to fourth segment, then smoothly scaled and an anal tuft of moderate length. Fore and mid femur and tibia hairy, hind tibia and tarsi with very long tufts of hair. Mid and hind tibiæ with spines. Fore-wing; costa nearly straight, slightly curved towards apex; apex slightly angled, outer margin slightly curved, on the inner margin near the base a moderate tuft of erect hair scales. Hind-wing with apex slightly rounded, inner margin fringed with long hair.

Type: *C. basipuncta.*

In classification I place this new genus after the genus Crithote,[7] Wlk. Jour. Linn. Soc. (1864), **7**, 182.

Crusiseta basipuncta sp. nov. (Pl. I, fig. 9.)

Palpi dark brown; head, collar and anterior half of thorax dark brown, changing to fuscous on the metathorax. Abdomen fuscous. Legs, except the tarsi, dark brown. Fore-wing with a straight, antemedial, yellowish line, oblique from the inner margin near the base to subcosta. Base and area along the costa purple-gray. A distinct, dark brown spot near the base and upper angle of the wing. Outer area dark brown, growing lighter towards the outer margin, which is purplish-gray. The tuft of hair scales at the inner margin dark brown. Hind-wing fuscous.

Length of wing, ♂: 16 millimeters.

Length of wing, ♀: unknown.

Manila, P. I.

Time of capture: August, 1905. (Charles S. Banks, collector.)

Type ♂, No. 3984, in Entomological Collection, Bureau of Science, Manila, P. I.

[7] Hampson: Fauna of Br. Ind., Moths (1894), **2**, 541.

GEOMETRIDÆ.

Boarminæ.

MILIONIA, Wlk., Cat. (1854), 2, 364.

Milionia pretiosa sp. nov. (Pl. I, fig. 10.)

♀, palpi and front, pale brown, shot with light blue, the sides of head whitish. Collar, thorax, abdomen and legs pale brown. A triangular, ochraceous spot at base of thorax; collar, tegulae, and coxae being especially shot with light blue. Fore-wing light ocherous, the apical half to lower angle of the wing, dark brown. An interrupted medial band from costa reaching the inner margin before the angle. At the base of wing an irregular spot, also dark brown. Hind-wing orange, a large, pale brown spot between costa and vein, which is covered by fore-wing. Another large dark brown spot between veins II and V; at the outer margin beginning on the upper angle a large, irregular spot; three round spots also along the outer margin at veins III, IV and V; the last one being the largest. There are some traces of pale, brownish spots along the veins next to the inner margin.

Length of wing, ♀: 25 millimeters.

Length of wing, ♂: unknown.

Manila, P. I.

Time of capture: July, 1905. (Alice and Fritz Worcester, collectors.)

Type ♀, No. 3591, in Entomological Collection, Bureau of Science, Manila, P. I.

PYRALIDÆ.

Schoenobiinæ.

SCIRPOPHAGA, Treitschke, Schmetterl. Eur. (1832), 9, 1, 55.

Scirpophaga virginia sp. nov.

Head, thorax, rear edges of abdomen, anal tuft and wings snow-white. The under side of the fore-wings, in the male sex, except the cilia, is grayish, as are fore-legs, and in both sexes the mid tibiæ with gray spots.

Length of wing, ♂: 7.5 millimeters.

Length of wing, ♀: 8.5 millimeters.

Manila, P. I.

Time of capture: September and October, 1905. (G. L. Araneta, collector.)

Type ♂, No. 4466, and ♀, No. 4351, in Entomological Collection, Bureau of Science, Manila, P. I.

This species is closely related to *Scirpophaga gilviberbis* Zell.

PYRALINÆ.

VITESSA, Moore, Lep., E. I. C. (1858), 299.

Vitessa splendida sp. nov. (Pl. I, fig. 11.)

♀, head yellow, third joint of palpi gray; collar and tegulæ dark, metallic-gray, bordered by yellow. Thorax yellow, growing lighter towards metathorax; at the middle of thorax two confluent spots of which the posterior one is the smaller. Abdominal segments banded dark gray and white; anal tuft orange-yellow. Legs gray, fore-coxæ yellowish, middle coxæ and middle and hind femora white below. Hind tibiæ banded with white. Fore-wing dark, metallic-gray. A yellowish, basal, subtriangular spot with the basal edge excised circularly. The spot extending from costa nearly to posterior margin and having its outer side parallel with the bases of 2 white, subtriangular, antemedial spots, the lower of which is the larger. Two postmedial, white spots, one subtriangular and subcostal, the other trifid [8] and subtriangular. The outer third of the wing longitudinally striated with a series of ten nearly parallel, whitish lines. Hind-wing white; outer half and a stripe along the costa dark, violet-gray. Cilia white.

Length of wing, ♀: 21 millimeters.

Length of wing, ♂: unknown.

Maao, Negros Occidental, P. I.

Time of capture: November, 1902. (Charles S. Banks, collector.)

Type ♀; No. 4567, in Entomological Collection, Bureau of Science, Manila, P. I.

This species is nearly related to *Vitessa suradeva,* Moore, Lep., E. I. C. P. 299, Pl. VII, fig. 7.

PYRAUSTINÆ.

PYRAUSTA, Schrank, Fauna Boica (1812), 2, 163.

PYRAUSTA, Hampson: Fauna of Br. Ind., Moths, (1896), 4, 429.

Pyrausta vastatrix sp. nov. (Pl. I, fig. 12.)

♀, palpi dark ochraceous, white below. Thorax and abdomen ochraceous, the last abdominal segments lighter. Fore-wing, ochraceous yellow with a reddish-ochraceous, excurved, antemedial, and a prominent postmedial zigzag line. A small speck in the cell and another at the discocellular, extending towards the postmedial line. The marginal and costal areas also reddish-ochraceous. Hind-wing pale, darker towards outer margin. A fine, brownish line at the outer margin. The fore-wing of the male somewhat darker, espcially the area between the ante- and postmedial lines, suffused reddish ochraceous.

[8] This is not well shown on the plate. The markings should be closer together.

Length of wing, ♀: 15.5 millimeters.

Length of wing, ♂: 11.5 millimeters.

Manila, P. I.

Time of capture: March, 1904. (Charles S. Banks and W. Schultze, collectors.)

Type ♂ and ♀, No. 1365, in Entomological Collection, Bureau of Science, Manila, P. I.

This species is very abundant in the vicinity of Manila, the caterpillar living in corn.

Pyrausta matuta sp. nov. (Pl. I, fig. 13.)

♀, palpi brown, white below; collar, thorax and abdomen yellowish, rear margin of abdominal segments whitish. General color of wings yellow. Fore-wing with a dark ochraceous antemedial, and a medial line, excurved in the middle and below the cell enlarged to a spot. Two postmedial lines of which the one next the outer margin is much excurved and runs together with the inner one at the inner margin. All these lines are very prominent. At the middle of the costa a small, brown streak. Hind-wing with a medial line, which is enlarged to a spot below the cell. Two postmedial lines, the inner one nearly parallel to the medial line; the outer one much excurved, meeting the inner one near the hind margin. Both wings with a strongly marked, brownish line at the base of ciliæ which are ochraceous. Wings below lighter. Fore femur and tibia light brown, first joint of tarsus light brown with the base and apex white. Mid femur light brown, all other parts, including hind legs, yellowish white.

Length of wing, ♀: 13.5 millimeters.

Length of wing, ♂: 10.5 millimeters.

Manila, P. I.

Time of capture: November, 1905. (P. G. Woolley and G. L. Araneta, collectors.)

Type ♂ and ♀, No. 4665, in Entomological Collection, Bureau of Science, Manila, P. I.

TINEIDÆ.

Hyponomentinæ.

Psecadia delicata sp. nov. (Pl. I, fig. 14.)

♂, antenna gray with a black spot at the base. Head, thorax and metathorax very light gray; palpi, the third joint black banded. Two black spots on the collar, a small one at the anterior part of the tegulæ and five black spots on the thorax. Abdomen, dark gray below, and anal tuft lighter. Fore legs dark gray, the other lighter, middle tibiæ with a dark spot, mid and hind tarsi dark gray. Fore-wing light gray with

15 black spots, of which 3 are near the base; 2 next and parallel to the outer margin, the others being scattered irregularly over the discal area of the wing. Hind-wing darker gray, with the cilia lighter, especially on the inner margin. Under side of wings dark, smoky gray.

Length of wing, ♂: 8.5 millimeters.

Length of wing, ♀: unknown.

Manila, P. I.

Time of capture: August, 1905. (Charles S. Banks, collector.)

Type ♂, No. 4186, in Entomological Collection, Bureau of Science, Manila, P. I.

ILLUSTRATIONS.

PLATE I.

FIG. 1. *Elymnias palmifolia* Schultze ♂.
2 a-d. *Adixoa tomentosa* Schultze ♂, ♀ and cocoons with pupal skin.
3. *Euchromia elegantissima* var. *diffusihelvola* Schultze ♀.
4. *Squamicapilla arenata* Schultze ♂.
5. *Pericallia integra* Schultze ♀.
6. *Deilemera browni* Schultze ♀.
7. *Ceryx macgregori* Schultze ♀.
8. *Remigia intextilia* Schultze ♂.
9. *Crusiseta basipuncta* Schultze ♂.
10. *Milionia pretiosa* Schultze ♀.
11. *Vitessa splendida* Schultze ♀.
12. *Pyrausta vastatrix* Schultze ♀.
13. *Pyrausta matuta* Schultze ♀.
14. *Psecadia delicata* Schultze ♂.

W. Schultze: New Lepidoptera of the Philippine Islands.

W. Schultze pinx.

Lith. Anst. v. Werner & Winter, Frankfurt a/M.

EDITORIAL.

The PHILIPPINE JOURNAL OF SCIENCE will begin a series of short editorial articles in the first number of Volume III, and will continue this policy in each succeeding number. These articles will consist of shorter notes concerning the work which is being carried on in the Philippines that otherwise would not be published, but which may be of interest to the readers of the journal. The body of the JOURNAL will be reserved for the longer papers embodying extended investigations, as heretofore.

PAUL C. FREER.

PHILIPPINE ARROW POISONS.

Many of the uncivilized and semicivilized tribes of the Philippines use poisoned arrows, principally for killing game. It is exceedingly difficult to discover the nature of the poisons which are used, as the wild man is of a very suspicious nature and will give misleading statements to anyone who endeavors to ascertain what plants he employs in their preparation. Many tribes claim the knowledge of the means of poisoning arrows to be a secret held only by the old men. Thus, Dr. Foxworthy, of this Bureau, after an extensive visit among the Negritos of Bataan Province, was told by these little people that they poisoned their arrows by using the bark and sap of two trees, one of which is *Diospyrus canomoi* and the other a tree called *bicag*. The latter was said to be very poisonous, but it was not identified. The Negritos in common with many other Filipino tribes, believe in the exceedingly deadly nature of *Diospyrus conomoi,* but the specimens of this plant which have been brought into the laboratory have been only very moderately toxic.[1] About two years ago, Commissioner Worcester succeeded in obtaining a small amount of arrow poison from the northern part of Mindoro near Bulalacao, evidently the sap of a tree. The sap was a milky liquid, the consistency of cream, specific gravity 1.065 at 15°. It had an exceedingly bitter taste and a high viscosity. The odor resembled that of sour bread dough, a slight fermentation had set in, the reaction was slightly acid. A quantity of

[1] Bacon, R. F.: *This Journal* (1906), **1**, 1028.

a rubber-like substance was coagulated from the solution when it was heated with a little dilute acid. The arrow poison gives a very slight precipitate with Mayer's solution, but an abundant one with phosphomolybdic acid. These reactions indicated the presence of a glucoside rather than of an alkaloïd, which suspicion was strengthened by the reduction of Fehling's solution by arrow poison which had been boiled with dilute acids. The milky sap was extracted with boiling benzol for two days. The extract was evaporated to dryness and the residue treated with boiling water. Basic lead acetate was added to the aqueous solution, it was then filtered and the excess of lead was removed from the filtrate by hydrogen sulphide. The filtrate was neutralized with calcium hydroxide and evaporated to dryness, the residue being extracted with hot alcohol, from which on cooling a small amount of substance separated in the form of small, crystalline, pearly plates. These crystals give an intense, golden-yellow color with concentrated sulphuric acid containing a trace of ferric chloride, which soon passes into a yellowish-red color. The lethal dose of these crystals in guinea pigs was found to be 0.00003 to 0.00005 gram per 100 grams of animal. As these reactions correspond very closely with those of the glucoside *antiarin* from *Antiaris toxicara* it was immediately suspected that the arrow poison was from this tree, but as this tree had never been found in the Islands, a Filipino was sent to this part of Mindoro to obtain more of the poison together with botanical material. A quantity of this as well as of the bark was procured, but no more of the poisonous sap. The tree was positively identified as *Antiaris toxicara* Lichen, identical with the famous poison Upas tree of Java. The bark of the tree is quite fibrous and the extract, after being boiled with dilute acids, has a peculiar and very distinctive odor like that of the sap when treated in the same manner. Six hundred grams of finely ground bark were boiled with water for twelve hours, the whole was then filtered, the adhering liquid pressed out and the solution evaporated to 1 kilo. It was now treated with basic lead acetate, etc., as in the former procedure with the sap of the tree and thus a small amount of crystalline material was obtained which with concentrated sulphuric acid containing a trace of ferric chloride gave a golden-yellow color, later passing into red (Kiliani). With one cubic centimeter of 3 per cent sodium carbonate solution to which three drops of a concentrated solution of picric acid had been added it gave, on heating, an orange color which on continued heating became more and more red (Wefers-Betinck). The bark also gives this last test very strongly. To obtain an idea of the quantity of antiarin in the bark of this tree, 100 grams of finely divided bark were extracted hot with 500 cubic centimeters of water and the filtered extract concentrated to

100 cubic centimeters. This extract was injected intraperitoneally into guinea pigs with the following results:

Number.	Weight of guinea pig.	Extract.	Extract per 100 grams guinea pig.	Remarks.
	Grams.	*cc.*	*cc.*	
1	570	5.8	1	Dead in 1 hour.
2	570	2.75	.5	Dead in 20 hours.
3	155	.40	.25	Dead in 8 hours.
4	160	.40	.25	Dead in 8 hours.
5	650	1.3	.20	Dead in 30 hours.
6	440	.90	.20	Dead in 27 hours.
7	205	.40	.20	Dead in 3 hours.
8	520	.70	.12	Survived.
9	720	.50	.12	Do.

Guinea pigs 8 and 9 showed almost no effects from the injection, while all the others developed violent symptoms soon after dose was given.

These experiments indicate that in 100 grams of bark there is 0.025 gram antiarin, as against 3.2 per cent of the glucoside found in the sap of the tree, if we can judge from the physiological experiments. The minimum fatal dose of this arrow-poison sap was 0.00156 cubic centimeter for 100 grams of animal, the calculation being based on a minimum fatal dose of antiarin of 0.00005 gram per 100 grams of animal.

The symptoms of antiarin poisoning have been well described by Seligmann.[2] The *Antiaris* sap loses its poisonous properties on boiling with dilute acids, being split up into a sugar called by Kiliam [3] antiarose and an indifferent body, antiarol, which seems to be identical with tetraoxybenzol trimethylether.[4] Many animals poisoned with antiarin were watched for twenty-four hours, but none recovered, as is often the case with curare arrow poisoning.

Other poisoned arrows have been obtained by members of this Bureau from the Tagbanuas at San Antonio Bay near the south end of Palawan. These arrows are used in blow guns and are 32 to 33 centimeters in length, being made of bamboo. Some of the arrows obtained have bone barbs fastened on the bamboo shaft with hemp fiber. All have a pith top to fit into the cane blow gun. The barb as a rule is 6 centimeters, the shaft 26 centimeters long and 3 to 3.5 millimeters in diameter. The poison is placed on the barb and shaft for a distance usually of about 5 centimeters and the amount of poison on each arrow is from 0.2 to 0.5 gram. This arrow poison has a consistency like rubber and it

[2] *Brit. Med. Journ.* (1903), **1**, 1129.
[3] *Arch. d. Pharm.* (1896), **234**, 438.
[4] Graebe and Suter, *Ann. Chem.* (*Liebig*) (1905), **340**, 220.

resembles in this respect the dried sap of *Antiaris toxicara;* the solution boiled with dilute acids gives the same peculiar and characteristic odor obtained from the antiaris sap under the same conditions. I was not able to isolate any antiarin from the small amount of material available, but could obtain color reactions which correspond with those from antiarin and also with those of the alkaloïds of *dita* bark. It is probable that, if the alkaloïds of *dita* bark are present, they are an unimportant constituent of the poison. The physiological action of this poison reminds me very much of that shown by antiarin as is evidenced by the following:

Guinea pig, weight 450 grams, 0.003 gram arrow poison inserted subcutaneously. In two minutes there is an excitement stage of the action; in four, a marked decrease in the rate of respiration is noted and the breathing labored. This stage is very rapidly followed by convulsive spasms and lack of muscular coördination. These convulsive spasms of the diaphragm and abdominal muscles last each about one second. This condition is soon followed by general convulsions, retraction of the head and extension of the fore and hind legs, the muscles being rigid for from 1 to 5 seconds. Each contraction of the muscles is explosive in character. Breathing becomes more and more difficult, the pupils are dilated, and the animal dies apparently of asphyxia. For several minutes after breathing has stopped there are muscular twitchings and irregular contractions of the heart, which finally stops in diastole. Death occurs in 8 minutes. There is no local irritation at the point of inoculation.

This experiment is typical of many others made on this powerful poison. It was found that 0.001 gram of the arrow poison will kill 500 grams of animal in 30 minutes, so that there is sufficient poison on one of these small arrows to kill from 100 to 250 kilograms of animal in half an hour.

Other animal poisons in the Philippines are prepared from fermented pineapple leaves, from *Sunasia Amori* Blanco, from *Lophopetalum toxicum* Loher and from *Strophanthus Cumingii* DC. These have not yet been investigated.

One case of poisoning from Dolores, Abra, came to this laboratory in which the poison used, a pounded fibrous bark, was identified as that of *Antiaris,* showing that the tree is probably not local to Mindoro and will doubtless be found in other parts of the Archipelago.

RAYMOND F. BACON.

FOOD AND DRUG INSPECTION.

The "Food and Drugs Act" of the Philippine Commission, passed May 18, 1907, is uniform with the United States act of June 30, 1906, in all of its provisions except those relating to the enforcement of the law by the courts and other officials of the Philippine Islands. The

Insular Collector of Customs, the Director of Health, and the Collector of Internal Revenue are authorized to make uniform rules and regulations subject to the approval of the Secretary of the Interior of the Philippine Islands for the enforcement of the law, and the Bureau of Science is directed to carry on all examinations of samples submitted by the three officials in whom the active enforcement of the law rests. The work of actively enforcing the law was commenced in the month of August, 1907, by the inspection of foods and drugs passing through the custom-house of the port of Manila. Later, the collection of samples was extended to other ports of entry of the Philippine Islands. During the first six months of the enforcement of the law, August, 1907, to February, 1908, over four hundred samples of foods and drugs were examined by this Bureau. These samples will be segregated into their respective classes and the analyses summarized from time to time. The butters, cheeses, and hams are represented as follows:

Butters.—Number of samples, 30: Australia, 14; Denmark, 3; France, 2; Germany, 2; Holland, 8; United States, 1. The analyses showed 9 to be imitations, 12 to contain a boron compound, and 9 legal.

Cheeses.—Number of samples, 24; England, 1; France, 3; Germany, 2; Holland, 15; Switzerland, 2; native, 1. The classes represented are Brie, cottage, Gruyère, Limburger, Roquefort, Stilton and the Dutch varieties. The analyses showed that 10 samples were not according to the standards and were probably made from skimmed milk. Fourteen were found to be legal.

Hams.—Number of samples, 30: Australia, 1; China, 3; England, 17; Japan, 1; United States, 8. The analyses showed 26 to contain nitrates and 7 a compound of boron.

H. D. Gibbs.

PURIFICATION OF COCONUT OIL.

Coconut oil, as it is expressed from sun or grilled dried copra, always contains a quantity of impurities—organic coloring matter, albuminoid bodies and a certain characteristic odor, all of which are objectionable for particular purposes for which the oil is otherwise well suited. While it is entirely possible to produce a pure oil directly from the nuts if special precaution in curing them is taken, the demand for highly refined oil does not seem to warrant the introduction of modern mechanical methods of desiccation at the present time, hence the numerous patents which are taken out from time to time and the frequent notices in the literature of new or improved processes for the production of pure coconut oil, refer to some subsequent chemical treatment of the commercially expressed oil itself. Clarification by filtration, subsidence or heating with or without the addition of coagulants is simple and economical of

application and, as generally practiced, removes all of the suspended foreign matter and most of the soluble impurities, producing a perfectly clear, light, amber oil of sufficient purity for soap stock, but it falls short of being completely free from odor and color. Therefore, further refining constitutes the only known means of producing an odorless and colorless product suitable for alimental or cosmetic purposes. The removal of the last traces of odor and color from coconut oil presents many difficulties in the way of subsequent clarification and risk of loss of oil and the methods of procedure are necessarily limited to the use of such chemical reagents as are harmless or are easily removed. In general, refining processes may be conveniently divided into (1) acid and (2) alkaline treatments, the former has not proved applicable for the production of oils for edible, cosmetic or lubricating purposes, because of the poisonous nature and otherwise harmful action of mineral acids. The alkaline process makes use of the hydrates or carbonates of the fixed alkalies, ammonia, caustic lime or magnesia, with or without the aid of heat. The efficiency of an alkaline treatment depends upon incomplete saponification, whereby the free, volatile, fatty acids, which are responsible to a large measure for the characteristic odor of coconut oil, are first neutralized and precipitated as a salt of whichever alkali is employed. If the alkali be added in excess of the amount necessary to neutralize the free acids and the oil is steamed or otherwise heated, then the neutral glycerides—that is, the oil itself—suffers partial decomposition and goes to augment the amount of soaps formed. Therefore, unless any alkaline treatment of a vegetable oil is carefully regulated, both as regards the amount of alkali used and the temperature employed, low yields of purified oil are obtained. All of the residues or "foots" go to form soap stock, hence the advisability is apparent of employing this process in conjunction with a market for the by-product. The main points to note in connection with refining by means of alkalies are, first, the minimum quantity of alkali necessary to effect the purification and, second, the right concentration of caustic lye which is unfavorable to the formation of emulsions. The minimum quantity of alkali can be determined accurately by testing the acidity of a small sample of the oil to be refined, or by the cut and dried methods of practical experience.

Ordinary commercial grades of coconut oil collected on the Manila market contain from 1 to 10 per cent of free fatty acids calculated as oleïc acid, and these percentages require approximately 0.15 to 1.5 parts, respectively, of caustic soda per 100 parts of oil. The caustic soda may be added to the oil either in the solid state with subsequent addition of water, or better, in the form of a caustic liquor previously prepared. The stronger the caustic liquor used the less the tendency to emulsion formation and the more rapid and complete the action, if proper mechanical devices for thoroughly mixing a strong lye with the oil are

used. If, after the addition of the caustic the oil is gradually heated to the boiling point of water, the soap separates in a granular condition and is easily removed by filtration or subsidence. The oil may now be steamed and washed with hot water until it is perfectly clear and neutral, and if the above treatment with caustic liquor and the subsequent steaming are properly conducted, the resulting oil will be found perfectly free from the well defined odor of the original oil and to possess the bland, fatty odor of pure melted lard.

Coconut oil is also considerably lightened in color by the above treatment, but in no sense can it be considered as a colorless oil. To remove the last traces of coloring matter from a vegetable oil is much more difficult than the destruction of the rancid odor, and in order to accomplish this completely it is necessary to subject the refined oil to some mild bleaching action which does not introduce harmful ingredients which would be difficult of subsequent removal. Of the many well-known methods of bleaching proposed for general use, hydrogen peroxide seems to be most favorable in this regard as it is easy of application and at its present price is not prohibitive. Sufficient dilute alkali should be added to neutralize any mineral acid it may contain and a slight excess favors the action of this reagent, at the same time having no saponifying action. Next in order of suitability is a dilute solution of chloride of lime slightly acidified with acetic acid. If the addition of acid and the temperature of the bleaching are carefully controlled, the chance of injury to the oil by free chlorine is a minimum and the result is a pure, water-white product.

George F. Richmond.

Harry M. Ickis, E. M.

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